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CONNECTION BETWEEN PHYSICAL CONDITION AND LIABILITY TO ACCIDENTS OF METAL MINERS

BY

R. R. SAYERS

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CONNECTION BETWEEN PHYSICAL CONDITION AND LIABILITY TO ACCIDENTS OF METAL MINERS[1]

By R. R. Sayers[2]

INTRODUCTION

According to the dictionary,[3] an accident is an event that takes place without one's foresight or expectation, often an undesigned, sudden, and unforeseen occurrence of an afflictive or unfortunate character. However, actual experience with accidents, the second most important cause of death in the United States,[4] and a more extensive and scientific inventigation of their causes indicate that from 75 to 90 per cent of accidents are avoidable.[5] This is borne out by the results of a three-year study of the accident records of 64,000 motor vehicle operators in New York[6] which show that certain drivers are prone to accidents, that accident experience is traceable to certain causes, and that accidents don't just "happen."

Occurrence and Cost of Accidents

It is estimated that 97,000 persons were killed by accidents in the United States in 1929 and 15,000,000 were injured. Of these, about 23,000 deaths were due to so-called industrial accidents. In a list of accident rates by industries, compiled by the National Safety Council[7] from reports of member establishments, mining heads the list in both frequency (74.43 per 1,000,000 man-hours worked) and severity (9.9 days lost per 1,000 man-hours worked). These figures are very much higher than for any other industry; the

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1 - Presented before the meeting of the Lake Superior Mining Section of the National Safety Council, Duluth, Minn., June 26-27, 1930. The Bureau of Mines will welcome reprinting of this paper, provided the following footnote acknowledgment is used: "Reprinted from U. S. Bureau of Mines Information Circular 6367."

2 - Chief surgeon, U.S. Bureau of Mines; surgeon, U.S. Public Health Service.

3 - Webster's New International Dictionary, edited by W. T. Harris and F. S. Allen, 1929.

4 - Accident Facts 1930, Public Safety Series No. 24, National Safety Council, 59 pp.

5 - Bowers, Edison L., The Value of a Man: Nat. Safety News, October, 1928, p. 83.

6 - Same reference as item 4.

7 - Same reference as item 4.

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industries showing figures most comparable to mining are meat packing with a frequency rate of 55.94 and a severity rate of 1.47, construction with a frequency rate of 50.41 and a severity rate of 4.52, and refrigeration with a frequency rate of 43.35 and a severity rate of 3.04.

While there is no way to determine the actual cost of all accidents from a monetary standpoint, estimates indicate that the cost will run into hundreds of millions of dollars annually.

Cost of accidents in metal mines.- The United States Bureau of Mines obtains accurate figures on the number of lost-time nonfatal accidents as well as fatal accidents in the metal-mining industry.[8] In 1926 the metal mines employed 127,623 men; 430 men were killed and 30,350 men received lost-time but nonfatal injuries as a result of accidents. Each of these fatal and nonfatal injuries averaged 114 days lost time, computing a fatality as 6,000 days lost time. This is equivalent to 3,523,944 days time lost due to accident, or at $5 per day per man, to a wage loss of $17,619,720. Deducting one-ninth of this figure for compensation paid, the metal miner loses in wage annually about $15,700,000, or about $122 per individual. This average loss per individual includes the cost of fatal accidents reckoned at 6,000 days or $30,000, but even if the loss in time due to fatal accidents be deducted, the average cost to each individual metal miner each year for nonfatal accidents is about $32. Estimating the loss to the metal-mine employer as about the same as that to the employee, the annual cost of metal-mine accidents to the employer is about $15,700,000 and to the employer and miner is $31,400,000.

Causes of Accidents

In a tabulation of the four most important causes of accidental deaths in the United States in 1928 by months,[9] automobiles came first in each of the 12 months, with falls second in each month except July, when drowning took second place and falls third. Figures based on the compensation awards made in New York State showed that falls were the most serious industrial injuries and in 1926-1927 and 1927-1928 caused the greatest number of deaths, but in 1928-1929 mechanical apparatus injuries were responsible for one more death. In 1923 the number of injuries due to falls, as compared with the total number of injuries, was 15.3 per cent; in 1929 the number had increased to 19.1 per cent. In the total amount of time lost, severity of nonfatal injuries and total cost, falls were the most serious industrial accidents.[10] "Butter fingers" and slippery feet are the chief causes of accidents in industrial plants, according to Edward O. Allard, manager of the safety engineering and inspection department of the American Surety Co. and its affiliated company, the New York Casualty Co. Altogether, said Mr. Allard,[11] nearly 11,000

8 - Denny, E. H., Accident Cost and Mine Safety: Information Circular 6166, Bureau of Mines, September, 1929, 6 pages.
9 - Same reference as item 4.
10 - Gernon, James L., Falls of Workers: Safety Eng., March, 1930, p. 122.
11 - National Safety News, Human Slips Cause Most Plant Accidents: January, 1930, p. 50.

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fatal and nonfatal cases were analyzed, and it was found that more than twice as many accidents were due to nonmechanical causes as were chargeable to machinery in operation, the former total being more than 7,700 as against less than 3,200. These figures emphasize graphically the importance of the human factor in the situation. Far-sighted manufacturers have installed guards on moving belts and machinery, and have safeguarded other points of hazard, because accident prevention is good business practice from every standpoint; yet it is evident that employees continue to suffer injuries, many of which are fatal, because they do not exercise sufficient care in performing such ordinary actions as walking and carrying.

Due to the improvement in safeguarding and the use of safety devices, accidents, have very largely been reduced where these protective measures have been employed. Accidents attributable to the human equation and caused by carelessness, indifference, and thoughtlessness are increasing and constitute the biggest problem in accident prevention to-day.[12]

Causes of accidents in metal mines.- During the year ending December 31, 1928, there were 273 fatal accidents and 22,483 nonfatal lost-time accidents in the metal mines of the United States.[13] Five causes of accidents out of a total of 39 causes listed were the source of more than half of the nonfatal accidents and nearly half of the fatal ones. That is, there were 22,756 accidents from all causes and 12,012 of these were due to the following five causes:

1. Fall of rock or ore from roof or wall.
2. Rock or ore while loading at working face.
3. Timber or hand tools.
4. Haulage.
5. Drilling.

In metal and nonmetallic mineral mines, during the period 1911 to 1925, accidents due to falls of men and material caused 39.55 per cent of the fatalities and 34.06 per cent of the injuries.[14]

It is not possible to say how many accidents are due to the individual and how many are due to conditions over which he has no control, but the fact that more than half the accidents in mines are due to operations in which personal responsibility has more opportunity to function and that investigations in industry in general show that about 90 per cent of the accidents are avoidable would indicate the part played by the individual in accident causation. According to statistics compiled by the Division of Safety and Hygiene of the Industrial Commission of Ohio, the five principal causes of accidents, in which the human element is largely predominant, persistently maintain their relative standing year after year.[15]

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12 - Safety Engineering, Are Industrial Accidents Increasing - If so, Why? October, 1927, p. 113.

13 - Adams, W.W., Metal-Mine Accidents in the United States, 1928: Bull. 320, Bureau of Mines, 1930, p. 35.

14 - Cannon, F.D., Accidents in Metal Mines Due to Falls of Men and Material: Rept. of Investigations 2944, June, 1929, 9 pp.

15 - Safety Engineering, Human Element Largely Predominant in Ohio Accidents: June, 1929, p. 257.

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VALUE OF HEALTH SUPERVISION IN INDUSTRY FROM THE STANDPOINT OF ACCIDENT PREVENTION

The consensus of opinion that seems to point toward the individual as the most important factor in accident causation leads to the conclusion that we must seek the type of information that can be found only through the critical examination of the human machine in order to reveal its deficiencies, either of structure or of function. This principle is applied to every complex device used in industry but is neglected with regard to the infinitely more complex device that guides the machinery. The operator who would not think of introducing untested machines into his mines or factories and who takes all reasonable precautions to see that his tools and appliances are properly constructed and adapted to the purpose for which they are to be used, will not hesitate to employ a large number of workers of whose physical capacity and health he has no conception, some of whom may be suffering with diseases that may endanger the safety and health of all the others and be a source of economic loss through lowered efficiency and increased compensation risk. For instance, a person suffering from epilepsy is not a proper one to carry a box full of dynamite, yet few employers inquire whether the men entrusted with such an important task are subject to this disease.

The two most important factors regarding the health of the individual in connection with his industrial life are (1) his physical condition when he enters employment and (2) the conditions of his working environment that may affect him afterward.

Physical Condition of Employees as Revealed by Physical Examination

A study of the results now available of physical examination in industry indicates that perhaps many of the accidents, attributed to the carelessness, indifference, or mental deficiency of the employee may be due to poor health or to undiscovered or unrealized physical defects.

The physical deficiencies of the men of the United States became glaringly apparent not only through the large number rejected entirely after examination for the draft during the war but through the fact that even those found eligible for service could not be used in battle until they had been physically trained. The rejection rate in the first draft in the United States for active military service of men between the ages 21 and 31 was 33 per cent. In Great Britain the rejection rate for ages 18 to 24 was 64 per cent; only 36 per cent were accepted in Grade 1 as eligible for full active military service. Pre-war reports on the examinations for the United States Navy,[16] while less representative of the general population are of interest as showing the types of physical deficiencies that are found among men having sufficient confidence in themselves to apply for enlistment:

16 - Fisk, E. L., Health Building and Life Extension: The MacMillan Co., New York, N. Y., 1923, p. 18.

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Number of men examined	82,592
Number of men rejected for all causes	51,167

Causes of rejections:

Defective eyes	11.4 per cent
Underweight	6.5 " "
Flat foot	6.08 " "
Defective teeth	5.9 " "
Deformities	4.3 " "
Varicocele or varicose veins	3.8 " "
Heart affections	2.8 " "
Height, under	2.6 " "
Poor physique	2.0 " "
Ear	1.7 " "
Genito-urinary - venereal	1.6 " "
Hernia or tendency to	1.6 " "
Skin disease	1.3 " "
Height and weight, under	1.1 " "
Tuberculosis or suspects	1.1 " "
Pyorrhea	1.08 " "
Tonsillar conditions	.72 " "
Genitourinary - nonvenereal	.66 " "
Nasal abnormalities	.57 " "
Febrile conditions	.46 " "
Mental disorders	.36 " "
Goiter or tendency to	.35 " "
Defective speech	.15 " "
Miscellaneous causes	3.41 " "
Total number rejected	62.00 per cent

A summary of the final report of the draft examination shows that among the total number examined, both accepted and rejected, there were found 468 men per 1,000 with defects worthy of record. However, physical examination of employees either for employment or periodically for improvement of health conditions made prior to the war indicate that the draft records underestimate the true conditions.[17]

In more than 100 plants where physical examinations of supposedly well employees were made by the Life Extension Institute wholly for the purpose of detecting physical impairments and offering counsel as to their correction, the following types of impairment were found in representative groups of more than 10,000 people actively engaged at work:[18]

17 - Same reference as item 16, p. 97.
18 - Same reference as item 16, p. 97.

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	Per cent
Class 1. No physical defect or impairment reported No modification of living habits required	0
Class 2. Slight physical impairment or defects requiring some form of hygienic guidance	10
Class 3. Moderate physical impairment or defect requiring some form of hygienic guidance or minor medical, dental or surgical treatment	41
Class 4. Moderate physical impairment or defect, medical supervision or treatment advised in addition to hygienic guidance	35
Class 5. Advanced physical impairment or defect requiring systematic medical supervision or treatment	9
Class 6. Serious physical impairment or defect urgently demanding immediate attention	5

Connection between physical condition and accident occurrence.- What is the connection between poor health and physical defects and accidents? The Hood Rubber Co.,[19] in a study of absenteeism, found that the accident rate for women rated as third class by physical examination was nine times greater than for those rated as first class. Among the men, those rated as third class showed nearly double the accident rate of those rated as second class. These findings were obtained in spite of the precautionary measure of special placement of third class persons in occupations involving low accident risk.

The relation of certain physical defects to accidents is apparent to any one, such as loss of an eye, an arm, a leg, or fingers. But physical and mental defects exist in every degree from the perfectly normal to a total loss of a member or of the function thereof. For instance, in the case of the eye, we may have a total loss of the eye, or of its function of vision, or of any degree between that and the normal, and the same is true with every other member of the body. Many employment men hesitate about hiring the man with one eye, but as they can not see the inside of the heart, they hire a crane man who is a menace to himself and every man working under every lift he makes. They turn down the man with two or more fingers off and hire the man with active tuberculosis, and fail to take precautions to prevent the spread of the disease. They will hire the man with two good appearing eyes, who may not be able to see the largest letters on the test chart. According to Schram,[20] there are many more men applying for work in the average industry whose eyes appear all right and yet who are almost blind in one eye than there are those whose eye defects are noticeable.

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19 - Sappington, C. O., Watch the Worker's Health: Nat. Safety News, October, 1928, p. 96.

20 - Schram, C. F. N., Industrial Health as a Purchasable Commodity: Safety Eng., May, 1925, p. 195.

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The most widespread physical defect, and therefore probably the one involved in the largest number of accidents, is defective vision. Studies in Pennsylvania have shown that more than half of the total accident claims arise from injuries to the eye.[21] There is no method for determining the percentage of accidents happening to other parts of the body that might have been avoided had the employees' eyesight been raised to the point of highest efficiency. The fraction of a second necessary for the normal, healthy eye to comprehend the circumstances of danger may be all that is needed to avoid a blow. In such an emergency, however, seriously defective vision is almost entirely helpless.

The statement has been made[22] that about 70 per cent of our muscular activities are initiated in response to impulses induced by our sense of sight. This fact, coupled with the average defective-vision conditions, may in large measure explain many accidents which, for want of a definite understanding of their causes, are at present ascribed to carelessness or heedlessness.

Various statements are made as to the number of persons in industry who have defective vision. One writer[23] states that 30 per cent of the persons who finish school and engage in business enterprises have defective vision, and that the lighting conditions in many of the establishments that they enter are even worse than those found in our schools. Therefore we should not be surprised to learn that investigation shows the percentage of workers having defective vision to be greater than the percentage of school children similarly handicapped. In some plants where thorough examinations were made it was found that 9 out of every 10 workers had defects of vision and that only a small number were correcting these defects with glasses. In other plants between 60 and 80 per cent of the total number employed had defective vision. It would appear on this basis that between 25,000,000 and 30,000,000 workers in this country have subnormal vision.[24]

In 1924, according to the report[25] of the Ford management to the Eyesight Conservation Council of America, 29,000 to 60,000 Ford employees examined had defective vision. The Ford report stated that although this was very high, the percentage of defective vision would have been still higher if more complete eye examinations had been made, which was not considered necessary except in special cases.

In some mines, in which the employees have been given a physical examination, the percentage of eye defects seems to be lower than in other industries. In an examination of the eyes of 800 employees of three mines of the St. Louis Smelting and Refining Works and the National Lead Co.,[26] only about 20 per cent of the men had defective vision. In an examination by the U. S. Bureau of Mines of 1,098 miners, 21.4 per cent were found to have

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21 - Kindy, W.H., Eyes that See Avoid Accidents: Nat. Safety News, July, 1929, p. 23.
22 - Simpson, R.S., Defective Vision and Industrial Accidents: Safety Eng., June, 1923, p. 220.
23 - Same reference as item 22.
24 - Same reference as item 22.
25 - Safety Engineering, Defective vision in Ford Plant: January, 1924, p. 44.
26 - Briggs, G.M., Striving for Safer Mines and Shops: Nat. Safety News, April, 1928, p. 13.

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defective vision in one or both eyes. Twenty of 81 applicants who presented themselves for examination for certificates as hoisting engineers in Utah had defective vision.[27]

In addition to defective vision, the many other defects found among industrial employees are potential causes of accidents, not only to the individual suffering from them but to other employees as well.

In the Bureau of Mines investigation mentioned above, in addition to defective vision, the following other physical defects were found: Three-tenths of 1 per cent of the men were totally deaf, 5.4 per cent had defective hearing, 3.8 per cent artificial teeth, 9.3 per cent cavities, and 35.2 per cent had pyorrhea. In reference to pyorrhea, this is one of the most frequent causes of rheumatism and lumbago. Forty-five per cent of the men had several teeth missing. As a whole, the examination of the teeth showed that 56.6 per cent of the men were in need of dental service. Chronic catarrh of the nose and throat was found in 1.7 per cent and enlarged tonsils in 15.1; 8.5 per cent of the tonsils were septic; .3 of 1 per cent had adenoids; .1 of 1 per cent had new growths (by new growths a cancer is usually implied) and 1 per cent had tumors, probably cancer. Examination of the abdomen disclosed that 2 per cent showed evidence of chronic appendicitis, and 4.6 per cent had hernia; in 2.3 per cent some enlargement of the glands of the body was present, indicating syphilis; 0.2 per cent had ankylosed joints; 2.6 per cent had flat feet; 2.2 per cent had bad varicose veins; 0.3 per cent had hard chancre at the time of examination; 0.9 per cent had gonorrhea; 5.7 per cent had varicocele; 5.1 per cent hydrocele; 1.1 per cent had acne, 0.1 per cent had eczema; 0.1 per cent psoriasis, and 0.1 per cent large scars that interfered with the performance of the part; 12.8 per cent had hemorrhoids; 1.8 per cent had miscellaneous diseases; 22 per cent had silicosis; 2.9 per cent had tuberculosis and silicosis; 1.1 per cent had tuberculosis alone; 9.6 per cent had high blood pressure, so high that it would be dangerous for them to work; 1 per cent had definitely grave heart disease, and 0.6 per cent had an irregular heart that probably was dangerous; 15 per cent had syphilis, indicated by a positive Wassermann; 54 per cent had not been vaccinated for smallpox; and 92 per cent had not been vaccinated against typhoid fever. To sum up, the physical examination of these 1,088 miners showed that 32.2 per cent were suffering from serious physical defects or diseases. The physical defects of 66 per cent of the men could be corrected by competent medical or dental treatment, and many of the others could be benefitted by such treatment.

There is not a great deal of material available showing the connection between the physical condition and accidents that the individual may experience. However, in a study of accidents among motormen and bus operators,[28] a canvass of the company's records showed that accidents did not distribute themselves impartially among the men who operated the cars. Half the accidents happened to less than a third of the operators. In one group of 200 men of ample experience

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27 - Murray, A.L., The Efficiency of Mine Labor with Special Consideration of Industrial Medicine and Health Conservation: Rept. of Investigations 2117, Bureau of Mines, April, 1920, p. 2.

28 - Slocombe, C.S., and Bingham, W.V., Men Who Have Accidents, Individual Differences Among Motormen and Bus Operators: The Personnel Jour., vol. 6, No. 4, December, 1927, 251-257.

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and maturity in the service, half of the accidents happened to only one-fifth of the motormen. Also high accident men were found to have a poorer general service record than low accident men. More of them tended to offend and to offend more often. All men over 50 years of age are given an annual medical examination by this company. Among the items measured and recorded are blood pressure, systolic and diastolic. The men over 50 years of age with abnormal blood pressure had on the average more than twice as many accidents as did men of comparable age and experience and with normal blood pressure. An interrelationship between these three factors--abnormality of blood pressure, number of delinquencies, and accidents--would suggest that in some measure the physiological condition probably accounts for both the number of delinquencies and the number of accidents.

Cottingham[29] gives the following interesting account illustrating the connection between accidents and disease:

> About four years ago while looking over the record of an accident repeater, I discovered that he had sustained 30 minor lost-time accidents within a period of less than two years. He was sent for and given a general physical examination. During the course of his examination he gave the history of having had repeated attacks of indigestion and had to be very careful in the selection of his diet. A diagnosis of chronic gastric ulcer was finally made, the man was operated upon, recovered and returned to work, and since that time has not been connected with an accident in any way.

Purpose and Extent of Health Supervision

With a realization of the impaired physical condition of such a large proportion of industrial workers, the importance and economic value of health supervision in industry becomes increasingly apparent.

The work of a plant physician should reach all departments and all activities of the organization. The physician who confines his activities to the plant dispensary is found to be of limited value to the industry with which he is associated. It is only as his influence reaches into the operating departments that the fullest measure of his service is realized. Co-existent with his curative and preventive activities should be a desire to see that men are placed at work for which they are physically qualified. The only method of attaining thisend is through the physical examination of workers and applicants for employment, to determine not only their physical condition but their mental attitude as well. Such examination should disclose in each case whether the worker is fit for the job for which he applies or is occupying or whether he should be given a different type of work because of some physical defect or weakness, or rejected if no suitable work is then available. More and more the effort is being made to find work for all.

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29 - Cottingham, M. D., Guarding the Worker's Physical and Mental Health: Nat. Safety News, April, 1928, page 34.

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Physical examinations are frequently made of workers to be transferred to more hazardous or exacting jobs. This often will prevent a future accident or breakdown in health.[30] The following is a good example of death that might have been avoided had such a type of health supervision been in force.[31] A man 67 years old, apparently hale and hearty and who boasted that he had not seen a doctor in 40 years, was employed in carrying barrels and bags of leather material weighing up to 100 pounds each and placing them on shelves and storage piles from 3 to 6 feet high. He had been handling bags and barrels in this plant for several years when one day after placing a barrel on the sorting table he complained of sudden pain in his stomach. He died the next evening from an internal hemorrhage. The autopsy showed chronic ulcers of the stomach which had ruptured as a result of the strain from lifting a heavy barrel.

Another case was that of a husky pressman in a printing establishment. He was over 6 feet tall and assisted in handling rolls of paper weighing about 1,500 pounds; two or three men occasionally lifted one end of the roll to put a block under it. One day he had been doing some such heavy lifting but evidently did not realize that he had injured himself and started home "jolly and laughing as usual." A little later he was found dead in the doorway of the plant. Autopsy showed that an artery near his heart had burst. There was evidence that he had had heart trouble for some time. A thorough physical examination probably would have revealed this trouble and indicated to him the danger of working at a job in which he had to do such heavy lifting.[32]

An interesting case, in which a cursory examination proved of great value, was that of a boy 16 years old but large for his age--in fact, a man in stature--who was employed in a shop. By struggling desperately he had finished the eighth grade in a grammar school. He was highly sensitive and somewhat morose and sullen because, although he was both larger and older than his fellow pupils, his scholarship was lowest. On two occasions within a week after employment he partially or wholly destroyed material upon which he was at work, and narrowly escaped injuring his hands. At first it was thought that his lack of familiarity with industry in general and with his own work in particular accounted for his mishaps. Fortunately, however, his foreman was a person with modern ideas and believed there was some better explanation for the boy's misfortunes. He therefore questioned the boy and took him to his desk where he subjected him to a rather crude eye test. This led to consultation with an oculist, who discovered that the boy had a serious visual defect and prescribed suitable correcting lenses. Two days later the boy returned to the shop wearing glasses. He was somewhat self-conscious at the start, but there was a notable improvement in both his mental and physical outlook. His foreman induced him to take a mechanical course at the night sessions of a trade school and four years later, at the age of 20, he was the assistant superintendent of the shop--a useful, self-respecting member of the community.[33]

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30 - National Industrial Conference Board, The Physician in Industry; A Symposium: Special Report No. 22, June, 1922, 98 pages.
31 - Beyer, David S., Causes of Accidents in Handling Material: Safety Eng., February, 1924, p. 101.
32 - Same reference as item 31.
33 - Same reference as item 22.

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In many cases a worker with physical defects or suffering from some diseased condition, often unknown to himself, is a cause of accidents to others as well as to himself. Bordley[34] reported a death and a serious accident in a steel mill from an overhead crane, both the result of defective vision in the operator of the crane. This man was given a thorough examination and his vision was found so defective that he had no idea of perspective. Another man with serious heart disease was allowed to operate a dummy engine in a mine. His heart failure and sudden death resulted in injury to several employees who were in the cage being hoisted by this engine.

As indicated by the above examples, physical examination is the keystone of industrial health work and serves as a background and stimulus for preventive medical work in industry.

The extent to which prospective employees should be subjected to physical examination depends in large part on the type of industry in which they are engaged. There are special types of occupation for which a more searching examination with respect to specific details is necessary, such as those in which particular importance is attached to eyesight, hearing, or possible previous beginnings of industrial disease, as among certain metal and chemical workers; also those in which the acme of physical perfection and endurance is required, such as engine drivers. However, all applicant examinations should be so carried out that the elements in the physical field covered would enable the examiner to detect:[35]

1. Active pulmonary tuberculosis.
2. Cardiac disease with potential or established decompensation.
3. Active or chronic venereal disease.
4. Acute contagious disease.
5. Chronic progressive disabling disease, such as Bright's and diabetes.
6. Potential and active focal infection.
7. Defective vision and hearing of a degree incompatible with the requirements of a given industry.

The chief objects of physical examination are:

1. To place the worker in the occupation that suits him best.

2. To detect the presence of remediable physical defects in order to enable the worker to correct them.

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34 - Mock, H. E., Industrial Medicine and Surgery: W. B. Saunders Co., Philadelphia, Pa., 1920, p. 330.
35 - Same reference as item 30.

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3. To determine the presence or absence of serious organic disease, either of which may have an important bearing on employment selection.

4. To prevent occupational disease, by excluding susceptible workers from specific hazards.

5. To prevent the spread of communicable disease, by the exclusion of infected persons.

Value to the employer of physical examination of workers.- The placing of all comers on jobs without any effort at a physical selection for their work is responsible for a great financial waste that can not be determined but has been estimated[36] at more than $500,000,000. Some of the sources of this waste are:

1. Labor turnover due to the employment of the unfit who later must be discharged because of inability to do the work or who are forced to stop work due to advancing disease. These latter have been a source of loss during the entire period of employment on account of the gradual decrease in their efficiency.

2. Increased industrial liability to accidents from those who, because of their physical condition, are subject to frequent accidents.

3. Absenteeism due to illness and lost-time accidents.

4. Liability to long disability compensation of those who suffer accidents that ordinarily would not be serious but, because of coincidental physical conditions, cause prolonged disability or death.

5. Loss of services of those who are healthy through contraction of contagious diseases. The acute contagious diseases are more common, but tuberculosis and syphilis also cause great loss.

Based on incomplete data, the Department of Labor estimates[37] the total annual number of disabling work accidents under normal industrial conditions as approximately 2,453,500. Of these, 21,230 result in death, 1,730 in permanent total disability, 105,620 in permanent partial disability, 540,350 in temporary

36 - Mock, H. E., Industrial Medicine and Surgery - A Resume of Its Development, Scope, and Benefits: Jour. Indust. Hygiene, vol. 1, 1919, 252-253.

37 - Davis, James J., Communication to the Committee on Labor, House of Representatives: Report No. 1392, 71st Congress, 1929.

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disability of from two to four weeks, and 433,000 in temporary disability over four weeks. The injured workmen and their dependents are reimbursed in accident compensation approximately $200,000,000 each year. This compensation is paid by the industrial employer. Another $35,000,000 is probably paid by the employer in the cost of turnover or replacement of these workers, which has been estimated to be $35 for each individual.[38] There is still another possible cost to the employer for which no estimates are available and that is the breakage or spoilage of machines and material that may occur as a result of accidents in which workers are injured or killed, or through impaired health and efficiency of the workers.

The employer should not make physical examinations with the sole idea of weeding out the unfit. It should be kept in mind that men must work and it is the duty of the plant physician to place men to the best of their abilities. He should remember that if a man is, for physical reason, a danger to himself, to his fellow man, or to the job, he should be adjudged unfit for the position. Other than this, a sincere attempt should be made to place all persons. One industrial surgeon thinks[39] that applicants having the following defects may be admitted to most factories without undue risk, provided they are selectively placed and watched:

1. Hernia of long duration which is completely or well held by a truss, provided the applicant has done work similar to that for which he is hired for four weeks preceding.

2. Varicose veins, provided ulcer and edema of ankles are absent.

3. Varicocele, if supported by suspensory.

4. Flat feet without symptoms: that is, pain in foot when applicant walks on toes or pain in back on bending over.

5. Deafness, except in special departments.

6. Defective vision, depending upon hazard and type of work.

7. Arteriosclerosis.

8. Endocarditis, unaccompanied by myocarditis.

9. Arrested tuberculosis - in special departments.

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38 - Same reference as item 16.
39 - Physical Examinations in Industry: Nat. Safety News, March, 1929, page 25.

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The following five types of defects he considers especially hazardous:

1. Arthritis of spine or sacroiliac region.

2. Arthritis of joints of long bones.

3. Old injuries to bones entering into a joint.

4. Infected tonsils and those suggesting a tendency to infection.

5. Potential hernia in Southern Europeans of stocky build.

Value of physical examination to the employee.- From an economic standpoint the worker is the one who pays the greater part of the enormous cost of industrial injuries. According to the Secretary of Labor,[40] the total annual wage loss resulting from these industrial accidents amounts to at least $1,000,000,000. The injured workmen and their dependents are reimbursed in accident compensation approximately $200,000,000 per year. Thus it will be seen that in spite of the compensation laws the workers must still bear four-fifths of the economic burden resulting from industrial injuries.

If, as has been estimated, 90 per cent of the accidents are due to the individual workers and probably 90 per cent of these workers have physical impairment or defects ranging from moderate impairment---requiring some form of hygienic guidance or minor medical, dental, or surgical treatment--to serious physical impairment or defect--urgently demanding immediate attention--and that probably 75 per cent of these impairments or defects could be cured or benefitted by treatment, it is of the greatest advantage to the individual that he find out his physical assets and liabilities. In addition to the economic loss in wages due to accidents, mentioned above, the worker must count the hours of physical suffering and the inconvenience to himself and his family, as well as the possibility of permanent, partial, or total disability with a loss in his earning power. Probably in many cases the years of mental distress outweigh the years of pain and suffering incident to the immediate accident. It is impossible to evaluate the actual cost to an injured person of reduced earning power and inability to advance in position. But for the resulting handicap he might have been advanced far up the ladder of supervising responsibility had not accident and disability cut short his prospective career. The whole theory of physical examination from an industrial standpoint is to fit a man to his job, to put him to work at a job which he is physically able to do. Physical examination is the one sure way to determine, in the best interests of the workman himself and of his family, how his earning capacity can be maintained and the period of his useful life lengthened.[41]

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40 - Same reference as item 37.

41 - Safety Engineering, What Shall We Do About Industrial Derelicts: January, 1929, page 26.

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INDUSTRIAL ENVIRONMENT AS A FACTOR IN ACCIDENT CAUSATION

In accordance with findings of physical examination prospective employees may be classed as follows:[42]

1. Those physically fit for any work.

2. Those physically underdeveloped, or with some slight anatomical defect; otherwise fit for any work.

3. Those fit only for certain employment when approved and supervised by the medical department.

4. Those unfit for any employment.

When persons are graded as Class I, this does not mean that they are entirely free from physical imperfections, but that the imperfections found are of little or no significance when considered from the industrial standpoint. Experience with physical examinations in industries would indicate that probably most of those in Class II can be restored to a normal physical condition by simple medical treatment and thus be fit for any employment. The reports[43] of one large corporation employing thousands of men show that 7 per cent of those applying for work were physically unfit but that by simple operations and other corrective measures 75 per cent of those rejected on original examination were sufficiently restored to normal to warrant their employment, thus the total net rejections amounted to less than 2 per cent of all those applying. Persons in Class III may be assigned employment suited to their abilities, provided proper medical attention is given to them and their condition checked at frequent intervals to determine whether or not their occupation is having an effect upon them.

However, individuals rated in Class III should not be employed in certain hazardous industries, and those in the first and second classes, especially the second, should be very closely supervised, since certain physical impairments that may be unimportant in some industries may put them below the limit of tolerance for the conditions to be encountered in the more hazardous industries. Periodical physical examination is especially valuable under these conditions.

Abnormal conditions of the air and bad illumination are two of the health hazards in the mining industry that may affect the worker in such a manner as to predispose to accidents.

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42 - National Industrial Conference Board, Inc., Medical Care of Industrial Workers: Chapter III. Physical Examination of Employees: New York, 1926.

43 - Murray, A. L., The Efficiency of Mine Labor With Special Consideration of Industrial Medicine and Health Conservation: Rept. of Investigations 2117, Bureau of Mines, April, 1920, 6 pp.

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Abnormal Air Conditions as Factors in Accident Causation

Abnormal conditions of the air may be due either to physical or chemical changes. The physical changes are abnormal temperature, humidity, and air movement, and the presence of dusts. Chemical changes may be due to variations in the normal constituents, as lowered oxygen or increased carbon dioxide; or to the addition of abnormal constituents, as carbon monoxide (white damp), hydrogen sulphide (stink damp), sulphur dioxide, methane (marsh gas, fire damp), hydrogen, and nitrogen.

Temperature, humidity, and air movement as causes of accidents.- According to Hope,[44] accidents in factories show a seasonal fluctuation similar to that shown in percentage of output, as they are more frequent in summer and under bad conditions of ventilation than in winter and under good conditions of ventilation. An exception occurs, however, in very cold weather if the temperature falls too low, more accidents occurring from slipping of tools, etc., if the hands become too cold. He mentioned that in a fuse factory the accidents were at a minimum at temperatures between 60 and 69°F. Above these temperatures there was a slight and progressive increase with rise of temperature, but with lower temperatures there was a well-marked increase, so that, in the case of women, there were two and a half times as many accidents when the external temperature was at or below freezing than when it was 47°F. or over, and the accidents among the men were twice as numerous. This result is largely due to the numbing effect of cold on the hands, especially when cold metal tools have to be held in them; but there is also a numbing effect on the brain.

From data collected in two munitions factories and a projectile factory on industrial accidents in relation to temperature, Vernon[45] observed that in both men and women the minimum accident frequency was at 65 to 69°. At lower temperatures it gradually increased to a similar extent in men and women, till at 50 to 54° it was 35 per cent greater than at 65 to 69°. At temperatures below 49° the frequency fell off slightly. This decrease may have been due to the fact that the workers were too cold to keep up their usual rate of production. In such a case they would expose themselves to less risk of accident. At temperatures above 65 to 69° the accident frequency showed only a slight rise for the women, but for the men it increased rapidly; and at temperatures above 75° it was 39 per cent greater than at 65 to 69°. Probably this difference was due to the fact that the work of the men was often of a heavier character than that of the women, and the greater the exertion required the more trying must be the effect of exposure to high temperatures.

Further light is thrown on this subject by Vernon and Bedford,[46] as to the relation of atmospheric conditions to accidents incurred in certain collieries. The results show that as the temperature of the seam rose (or the kata cooling powers fell), the accident frequencies of the colliers and

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44 - Sayers, R.R., and Davenport, Sara J., Review of Literature on the Physiological Effects of Abnormal Temperatures and Humidities: Public Health Reprint No. 1150, 1927, 31 pp.

45 - Same reference as item 44.

46 - Farmer, Eric, and Chambers, E.G., A Study of Personal Qualities in Accident Proneness and Proficiency: Industrial Health Research Board Report 55, 1929, 54 pp.

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trammers, who work at or near the coal face, tended to increase, while the accident frequencies of the haulage men and other employees, who work in the airways where the temperatures are lower, remained practically constant throughout.

These preliminary conclusions have recently been confirmed through another investigation by Vernon and Bedford relating to the causes of absenteeism in a group of collieries employing 23,000 miners. In this inquiry, it was again shown that accident frequency was closely associated with temperature, but that this association was limited to the less severe type of accident, the more serious accidents showing no such relationship, for whereas accidents involving absence of less than 10 days increased fivefold within a temperature range of 60 to 80° F., the major accidents were slightly less numerous at the highest temperatures than at the lowest, whilst the less severe accidents occupied an intermediate place. This differentiation between major and minor accidents is attributed by the authors to the more ready tendency on the part of the men working at high temperatures to report small accidents.

One of the most striking results of the installation of a cooling plant in the Morro Velho mine[47] was the fall in the accident rate. In the 16 months (August, 1919, to November, 1920, inclusive) previous to the starting up of the plant there occurred 20 deaths through underground accidents and four cases of disablement, the total liability for compensation involved in connection with these accidents being 80,675 milreis. In the following 16 months (December, 1920, to March, 1922, inclusive) there were six fatal accidents underground and four cases of disablement, the amount of compensation involved being 35,820 milreis (one milreis is about 50 cents).

Sometimes accidental deaths may be the indirect result of the faintness caused by the effect of the heat on the circulation. As an example, Raymond[48] mentions the case of a man who fell down an upcast shaft, probably because he was overcome by the heat while putting in timbers.

While the direct action on the body of increased temperatures and humidity may in itself predispose the individual to accidents, there are other points to be considered. One of these is the fact that a moderate increase of temperature--within physiological limits--will augment the action of gases. In a study of the effects of exposure to low concentrations of carbon monoxide, it was[49] found that high temperature and humidity, with a given concentration of carbon monoxide, caused more rapid combination of the gas with hemoglobin than did normal conditions of temperature and humidity. This is of importance under conditions in which carbon monoxide and other toxic gases may be encountered.

The correlation of accident frequency with dry bulb and wet bulb

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47 - Same reference as item 44.
48 - Same reference as item 44.
49 - Sayers, R. R., Meriwether, F. V., and Yant, W. P., Physiological effects of Exposure to Low Concentrations of CO: Public Health Repts., Reprint No. 748, 1922, 16 pp.

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temperatures was fairly high for coal-face workers, according to a survey made of ten collieries in England,[50] and was quite high for other underground workers. The correlation of accidents was, on the whole, lower than the correlation with temperatures, because of the disturbing effect of the air velocity factor. While the accident frequency was practically constant at all velocities under 60 feet per minute, it showed a considerable increase at a mean velocity of 72 feet; at a velocity of 204 feet they were 68 per cent more numerous. The accident severity was high at very low velocities, but fell to a minimum at a velocity of 30 to 59 feet per minute; then it rose rapidly, like the accident frequency. There can be no doubt that a certain amount of air movement is necessary for the attainment of maximum working capacity, and presumably the same conditions hold for the attainment of minimum accident liability. Arguing from the small amount of evidence adduced, the investigators concluded that probably accidents reach their minimum when the air currents have a comparatively low velocity, such as 30 to 60 feet per minute. The investigators suggest that the increase in accidents at higher velocities may be due to the chilling of the men when they are temporarily resting from work and, as a consequence, they would become stiffer and clumsier in their movements.

According to the annual report of the Secretary of Mines of South Africa,[51] on the Witwatersrand the mine having the highest death rate from accidents during 1925 was the Village Deep with an accident rate of 4.35 per 1,000. The report states that the high temperature in this mine is no doubt having an indirect effect in causing accidents. A special investigation was made owing to four cases of sudden death that occurred between September 29, 1925, and January 1, 1926 in this mine. Since August 20, 1926, managers have been required to report cases of heat apoplexy just as they do serious accidents.

Since some of the physiological effects of high temperatures and humidities are dizziness, physical weakness or exhaustion, and inability to think quickly or accurately, it is evident that a person suffering from the effects of exposure to such conditions might show an increased tendency to experience accidents. Probably the physiological effect of abnormally high temperatures most likely to predispose the subject to accidents is that on the circulatory system, shown especially by the increase in pulse rate. After bringing out a car 1,200 feet in the 1,800 level of the Julia Mine of the Comstock lode, Nevada, in an air temperature of 108 to 110°F., a carman had a pulse rate of 140 per minute, which fell to 64 after a rest at the station. In the case of a visitor, the pulse rose from 60, his normal rate, to 120 after walking through the drift.[52] Though no arbitrary rate at which certain symptoms occur has been determined, the consensus of opinion indicates that very uncomfortable sensations are felt after the pulse rate exceeds 135 per minute, and that the atmospheric condition becomes almost unbearable when the rate exceeds 160 per minute.

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50 - Vernon, H. M., Bedford, T., and Warner, C. G., A Study of Absenteeism in a Group of Ten Collieries: The Colliery Guardian, August 31, 1928, p. 819-823.

51 - Sayers, R. R., Physiological Factors of Mine Ventilation: Information Circular 6089, Bureau of Mines, November, 1928, 16 pp.

52 - Same reference as item 44.

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The rise in blood pressure also no doubt contributes to the discomfort. At 30 per cent relative humidity the change begins around 120°F.; at 60 per cent, around 104°F.; and at 100 per cent, around 92°F. Subjects describe the sensation felt on reaching the unbearable conditions as follows: First, a slight palpitation of the heart occurs, which increases in severity until a feeling of floating in the air is experienced. This is accompanied by dizziness, and frequently with a numbness or soreness of the face, and with nausea. The New York State Ventilation Commission[53] found that at a temperature of 75° F., 50 per cent relative humidity, there was only a negligible change in the heart rate; at 86°F., 80 per cent relative humidity, there was an increase in the rate of the heart in the standing position, and in the reclining position a negligible average decrease; at a temperature of 100.5° F., average humidity of 86 per cent, exposure for a period of 2.43 hours was accompanied by an average increase in the rate of the heart of 28 beats per minute, or 43 per cent, the average maximum increase being 41 beats, or 63 per cent. Exposure while performing physical work to 101° F., 87 per cent humidity, for 2.5 hours was accompanied by an average increase of systolic pressure amounting to 12.6 mm., or 12 per cent, and of diastolic pressure of 1.4 mm., or 2 per cent, the respective average maximums being 22 and 16 per cent.

Mine dusts as factors in accident causation.- The physiological effect of dusts as a factor in accidents probably is mostly indirect, through a general lowering of the physical efficiency. During the World War , however, British[54] miners were found to be so susceptible to carbon monoxide poisoning that an order was issued prohibiting them from working in any place where the presence of gas was suspected. A considerable porcentage of the miners from Australia and South Africa, especially the older men who had worked in the gold mines, suffered from silicosis. This rendered them more susceptible to carbon monoxide and they suffered more severely from the effects and took longer to recover. This increased susceptibility would, of course, render a man more liable to accidents from gases encountered in gassy mines or in case of mine fires necessitating exposure to smoke.

According to Collis,[55] the accident rates among the various coal fields in England for 1910 to 1912 place death rates in the coal fields in the same order as the death rates for all causes; and the same is nearly true with regard to the rates for each of the respiratory diseases. The deduction, he thinks, obtrudes itself that conditions leading to ill health, particularly conditions of the kind that terminate in death from respiratory disease, have also some underlying influence on accident causation; probably the ill-being which the conditions cause is at the root of the matter. "Carelessness" with regard to safety is largely an expression of ill-being; a man who is healthily alert is not naturally careless. According to Collis, this deduction receives some support from the figures of the average annual deaths per million persons employed at all mines in England. These figures indicate a very striking

53 - New York State Commission on Ventilation, 1923, 620 pp.
54 - Same reference as item 44.
55 - Collis, E. L., The Coal Miner: His Health, Diseases, and General Welfare: Jour. Indust. Hygiene, vol. 7, No. 7, 1925, pp. 221-243.

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decrease in the number of accidents, for the prevention of which much has been done by research and regulation, and an improvement less marked in the number of accidents due to falls of ground, in the prevention of which, though many are classed as unavoidable, personal care plays a predominant part. On the other hand, no improvement is evident in the number of accidents on haulage, where safety depends far more on the personal factor than on regulation, and in which the work of the individual is not open to close supervision. Collis feels that if the same reduction that has been effected for explosions and shaft accidents could be obtained for haulage accidents and falls of ground, the mining industry would lose its unenviable reputation.

Chemical changes in the normal constituents of the air as factors in accident causation.- In studies made by the psychological laboratory of Mellon Institute of Industrial Research[56] it was observed that ordinary fatigue and the conditions of narcosis from drugs and from oxygen depletion depend alike upon asphyxiation of the muscle cells. An attempt was made to determine what degree of delayed response and impaired efficiency, as indicated by the physiological and mental signs, may be taken as an objective index of fatigue. Throughout all tests the powers of concentration, steadiness, persistence, substitution, calculation, memory, and the ability to sustain continuous reaction ran such close parallels with increasing symptoms of asphyxiation that, according to Mr. Johnson, head of the laboratory, no distinction existed between so-called "nervous" fatigue and physical exhaustion. Almost the entire range of disturbances observed related to factors in the physical environment, that is to say, to oxygen supply, air conditions, and comfort. A man gets drunk on too low an oxygen intake, asphyxiated by the combustion products within his muscle cells. According to Mr. Johnson, three conditions counterfeit this picture of alcoholic poisoning: (1) A diminished oxygen supply due to great dilution of the air by means of other gases, or in rarefied air of high altitudes, or in inclosed spaces polluted by carbon monoxide; (2) a lowered rate of cell respiration caused by alcohol or other drugs; and (3) induced fatigue, when cells burn faster than the toxic products of incomplete combustion can be washed away by the blood stream. The above physiological reactions, especially delayed response and decreased powers of concentration, would predispose a person affected thereby toward accidents.

The connection between poor physical condition, hazardous environment, and accidents is shown by the following incident which happened to an employee of the Eastman Kodak Co.[57] This employee, a chemical worker, had not been feeling well for several days. He had taken a long ride to Niagara Falls and had greatly overeaten. Returning to work on Monday morning he was exposed to an unusual amount of gases, through a leak in an acid line. He, however, received no more than four or five other men who were working with him and he said that he had frequently inhaled more fumes than he had at this particular time. However, on the following day his temperature was 105 and his pulse 140.

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56 - Heating, Piping, and Air Conditioning, Drunk on Bad Air: November, 1929, p. 616.

57 - Slater, B. J., How a Medical Department May Contribute to Safety in the Chemical Industry: Safety Eng., November, 1924, p. 216.

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He was deeply cyanosed and all the doctors who were taking care of him practically despaired of his life, but he finally recovered. This is a case of a man who was not in good physical condition and was much more affected by adverse environment than usual and much more than others similarly exposed.

Bad Illumination as a Factor in Accident Causation

Bad illumination is a two-edged sword. It causes accidents directly by obscuring hazardous conditions and indirectly by affecting the vision of the workers. According to the First Report of the Departmental Committee on Lighting in Factories[58] increased prevalence of accidents, damage to eyesight and health, and diminished output are the result of unsatisfactory lighting conditions. A large industrial insurance company[59] has estimated that 18 to 25 per cent of industrial accidents are due to inadequate or improper illumination. The causes of accidents traceable to poor lighting may be due to

1. Insufficient lighting in dark corners.
2. Improper lighting effects:
    a. Glare or blinding sources.
    b. Shadow production in dangerous places.
    c. Too great contrast at light on working place compared with other places.

Another statement[60] is that faulty lighting and poor eyesight are the major factors in one out of every eight accidents.

In investigations of industrial lighting conditions, Price[61] found that in New York State 36.7 per cent of the laundries inspected, 49.2 per cent of the candy factories, 48.4 per cent of the printing places, 50 per cent of the ice cream plants, and 64.8 per cent of the chemical establishments were inadequately lighted. Hardly a trade was investigated that did not have a large number of inadequately lighted establishments. The Joint Board of Sanitary Control reported that one-third of the shops in the cloak and suit industry of New York City were found to be inadequately lighted. The statement was made by the Travelers' Insurance Co.[62] that approximately 25 per cent of the accidents classed as unavoidable are due directly or indirectly to poor illumination.

Conditions of illumination, of course, are much poorer in the mines than on the surface. Llewellyn[63] points out that, although the human eye is capable of receiving light impressions of extraordinary range, from the light of the midsummer sun, estimated at 40,000 foot-candles, to a flicker of a

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58 - Llewellyn, T.L., Miners' Nystagmus: Its Prevention and Cure: Empire Mining and Metallurgical Congress, London, June 3-6, 1924.
59 - Sappington, C.O., Watch the Worker's Health: Nat. Safety News, October, 1928, p. 96.
60 - Simpson, R.E., Light, Sight, and Safety: Safety Eng., August, 1924, p. 77.
61 - Price, G.M., The Modern Factory: New York, 1914, p. 232.
62 - Same reference as item 62, page 234.
63 - Same reference as item 59.

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match on a dark night a hundred yards away, still it must be adapted to the light present, and the process of "dark adaptation" by which the miner "gets his eyesight" after descending into the mine, and of "light adaptation", the reverse change on his return to the surface, are of great importance in the consideration of underground lighting conditions. Rapid changes from light to darkness or from darkness to light are unpleasant. Physiological considerations point to the necessity for adequate and uniform illumination, avoidance of glare, and a gradual process of dark adaptation. Illumination in mines may be deficient due to the low candle power of the lamp used, the limited area illuminated by the lamp, and the lack of contrast. In England this poor illumination in the coal mines is generally considered as the cause of the eye disease called nystagmus. The eye strain resulting from poor light is not only harmful to the eyes but possibly also to the general health of workers, and thus indirectly may predispose the individual to accidents.

SUMMARY

1. It is estimated that 97,000 persons were killed and 15,000,000 injured by accidents in the United States in 1929. Of this number about 23,000 were industrial accidents. Mining headed the list in frequency and severity of accidents.

2. It is estimated that the cost of accidents to the metal miners in wage loss is $17,619,720 and to the employer at least $15,700,000, or a total of $31,400,000 for the industry.

3. In total amount of time lost, severity of nonfatal injuries, and total cost, falls are the most serious industrial accidents.

4. Accidents due to improvement in safeguarding and use of safety devices have been very largely reduced, but accidents due to the human equation are increasing and constitute the biggest problem in accident prevention to-day.

5. In 1928 there were 22,756 accidents, from all causes, in metal mines. The fact that more than half of the accidents in mines are due to operations in which personal responsibility has more opportunity to function and that investigations in industry in general show that about 90 per cent of the accidents are avoidable indicates the necessity of concentrating on the individual in accident-prevention work.

6. The first step in accident prevention, therefore, would seem to be a complete physical examination of the worker to determine his ability to perform the work for which he is employed.

7. Physical examination of men for the army during the war and also examinations of workers in the industries indicate that from 75 to 90 per cent of the workers have some defect or impairment of health and that probably in 50 per cent these defects or impairments are of enough importance to reduce efficiency and increase liability to accidents.

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8. One of the most important and widespread impairments found among industrial workers is defective vision. In some plants 9 out of every 10 employees were found to have defective vision; in other plants, 60 to 80 per cent were found to be similarly handicapped. In a study made by the Bureau of Mines of 1,098 miners, 21.4 per cent were found to have defective vision in one or both eyes.

9. Other defects than those of vision, as well as diseases, influence the accident tendency of the persons affected. In a study of accidents among motormen, it was found that those with abnormal blood pressure had on an average twice as many accidents as did men of comparable age and experience who had normal blood pressure. An instance is given of one man who sustained 30 minor lost-time accidents within a period of less than two years. On examination he was found to be suffering from chronic gastric ulcer. Since recovery from an operation and returning to work he has not been connected in any way with an accident.

10. Employees should be given a physical examination before employment and at intervals thereafter. The extent and thoroughness of the examination and the frequency of reexamination should depend upon the type of occupation and the degree of health hazard involved.

11. The chief objects of physical examination are:

1. To place the worker in the occupation that suits him best.

2. To detect the presence of remediable physical defects in order to enable the worker to correct them.

3. To determine the presence or absence of serious organic disease, either of which may have an important bearing on employment selection.

4. To prevent occupational disease, by excluding susceptible workers from specific hazards.

5. To prevent the spread of communicable disease, by the exclusion of infected persons.

12. The value to the employer of physical examination is indicated by the fact that the financial waste due to placing all comers on jobs without any effort at physical selection for their work has been estimated at more than $500,000,000. Some of the sources of this waste are:

1. Labor turnover due to the employment of the unfit who later must be discharged because of inability to do the work or who are forced to stop work due to advancing disease. These

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latter have been a source of loss during the entire period of employment on account of the gradual decrease in their efficiency.

2. Increased industrial liability to accidents from those who, because of their physical condition, are subject to frequent accidents.

3. Absenteeism due to illness and lost-time accidents.

4. Liability to long disability compensation of those who suffer accidents that ordinarily would not be serious but, because of coincidental physical conditions, cause prolonged disability or death.

5. Loss of services of those who are healthythrough contraction of contagious diseases. The acute contagious diseases are more common, but tuberculosis and syphilis also cause great loss.

13. From a monetary standpoint the value of physical examination to the employee is still greater than to the employer. According to the Secretary of Labor, the total annual wage loss resulting from industrial accidents amounts to at least $1,000,000,000. The injured workmen and their dependents are reimbursed in accident compensation approximately $200,000,000 each year. Thus it will be seen that in spite of the compensation laws the workers must still bear four-fifths of the economic burden resulting from industrial injuries.

14. It has been stated that 90 per cent of the defects and health impairments are either curable or can be greatly benefited by medical treatment, therefore physical examination to determine what these are is the first step toward their correction. Physical examination from an industrial standpoint also is to fit a man to his job.

15. The reports of one large corporation employing thousands of men show that 7 per cent of those applying for work were rejected on examination, but that by simple operations and other corrective measures 75 per cent of those rejected were sufficiently restored to normal to warrant their employment. The net tons of rejections amounted to less than 2 per cent of those applying.

16. Abnormal conditions of the air and bad illumination are factors in the environment influencing accidents through their effect on the individual and his health and comfort.

17. Some of these conditions are physical changes in the air, such as abnormal temperatures, humidities, and air movement, and the presence of dusts; and chemical changes, such as lowered oxygen or increased carbon dioxide content of the air, or the addition of abnormal constituents as carbon monoxide, hydrogen sulphide, sulphur dioxide, methane, hydrogen, and nitrogen. From data collected on industrial accidents in relation to temperature it was observed that in both men and women the minimum accident frequency was at 65 to

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69° F. At lower temperatures it gradually increased to a similar extent in men and women, till at 50 to 54° it was 35 per cent greater than at 65 to 69°. At temperatures above 65 to 69° the accident frequency showed only a slight rise in the women, but in the men it increased rapidly, and at temperatures above 75° it was 39 per cent greater than at 65 to 69°. Probably this difference was due to the fact that the work of the men was often of a heavier character than that of the women, and the greater the exertion required the more trying must be the effect of exposure to high temperatures.

18. One of the most striking results of the installation of a cooling plant in the Morro Velho mine was the fall in the accident rate. In the 16 months (August, 1919, to November, 1920, inclusive) previous to starting up the plant 20 deaths occurred through underground accidents and 4 cases of disablement, the total liability for compensation involved in connection with these accidents being 80,675 milreis. In the following 16 months (December, 1920, to March, 1922, inclusive) there were six fatal accidents underground and four cases of disablement, the amount of compensation involved being 35,820 milreis.

19. The effect on accidents of air movement is shown by investigations in 10 collieries in England. While the accident frequency was practically constant at all velocities under 60 feet per minute, it showed a considerable increase at a mean velocity of 72 feet. The accident severity was high at very low velocities, but fell to a minimum at one of 30 to 50 feet per minute; then it rose rapidly, like the accident frequency. From the small amount of evidence adduced, the investigators concluded that probably accidents reach their minimum when the air currents have a comparatively low velocity, such as 30 to 60 feet per minute.

20. The physiological effect of dusts as a factor in accidents probably is mostly indirect, through a general lowering of the physical efficiency. However, it has been found that miners suffering from silicosis are more susceptible to deleterious gases, especially carbon monoxide, and would be more liable to accidents from gases encountered in mines.

21. The physiological effects of various gases, such as delayed response and decreased powers of concentration, would predispose an affected person toward accidents.

22. Poor illumination causes accidents directly by obscuring hazardous conditions and indirectly by affecting the eyes of the workers so as to result in defective vision, which in turn leads to accidents. A large industrial insurance company has estimated that 18 to 25 per cent of industrial accidents are due to inadequate or improper illumination.

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